(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 587 192 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93115068.4**

(51) Int. Cl.5: **B41J 2/295**

(22) Date of filing: **04.07.89**

This application was filed on 20 - 09 - 1993 as a divisional application to the application mentioned under INID code 60.

(30) Priority: **08.07.88 JP 168894/88**
11.11.88 JP 283897/88

(43) Date of publication of application:
16.03.94 Bulletin 94/11

(60) Publication number of the earlier application in accordance with Art.76 EPC: **0 350 258**

(84) Designated Contracting States:
DE ES FR GB IT

(71) Applicant: **FUJITSU LIMITED**
1015, Kamikodanaka
Nakahara-ku
Kawasaki-shi Kanagawa 211(JP)

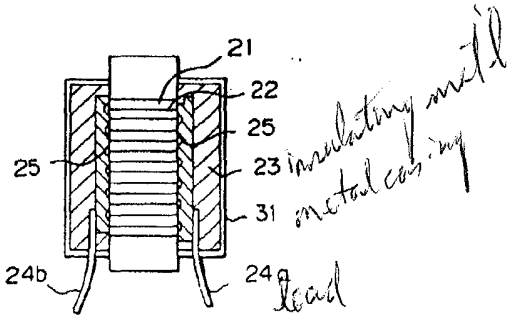
(72) Inventor: **Yano, Akio**
8-26-7-301, Kinuta,
Setagaya-ku
Tokyo 157(JP)

(74) Representative: **Fenlon, Christine Lesley et al**
Haseltine Lake & Co.
Hazlitt House
28 Southampton Buildings
Chancery Lane
London WC2A 1AT (GB)

(54) Electro-distortion device.

(57) An electro-distortion device used, for example, as an actuator in a dot matrix printing head includes a stack of laminations (21) made of an electro-distortion material such as a piezo-electric ceramic material, with respective electrodes (22) sandwiched between successive laminations, such that the application of an electrical potential difference across the or each lamination brings about a change in the extent of the stack, along its stacking axis. In order that short circuiting between respective electrodes is prevented, the electrodes and the laminations are surrounded by an insulating material (23) such as an epoxy resin, which is in turn preferably encased in metal (31).

Fig. 1



EP 0 587 192 A1

This invention relates to electro-distortion devices which are used, for example, as actuators in dot matrix printing heads.

Recently, high-speed wire-dot printing heads have become widely used and, accordingly, in order to drive the dot-impact wires or rods of such high speed printing heads, actuators comprising electro- or magnetic-distortion devices have been developed and used instead of electromagnet type drive elements.

The use of such electro-distortion devices in a printing head has been proposed in "NIKKEI (Japan Economic) MECHANICAL", page 92, March 12, 1984, for example, the proposed electro-distortion device being made by the steps of: preparing a plurality of green sheets made of piezo-electric ceramics, forming a metal paste film on one of the surfaces of each of the green sheets to form an inner electrode, and laminating and sintering the plurality of green sheets.

A printing head using such an actuating device must be provided with means for effectively enlarging the very small displacements of such an actuating element so as to drive the dot-impact wires or rods adequately.

A dot-matrix printing head may include an array of dot-printing devices operable selectively to cause respective dot-defining portions thereof to impinge on a printing medium to cause respective dots to be printed.

JP-A-59-16767 proposes a dot-printing device, suitable for use in such a dot-matrix printing head to achieve such enlargement, which device may be considered to comprise a flexible member, fixed at one end thereof to a support structure of the head and having at its other end the said dot-defining portion of the device, and also to comprise an electrically controllable actuator operable to impose movement on the flexible member, substantially perpendicular to the main plane of that member, at an actuating position thereon so as to bring about such impingement of the dot-defining portion of the device, the flexible member being laminar in form, at least in the region between the said one end and the actuating position, and the distance of the said actuating position from the said one end of the flexible member of the device being small in comparison with the distance of the actuating position from the said dot-defining portion of the device.

A suitable form of dot printing device is proposed in US-4,362,407, which employs an actuator substantially including an electro-distortion device comprising a stack of laminations made of an electro-distortion material with respective electrodes included at different positions in the stack, each of which electrodes is sandwiched between two successive laminations of the electro-distortion material, and externally accessible connection means operable to apply an electrical potential between successive electrodes in the stack, thereby to bring about a bending deflection in the stack, with the deflection being perpendicular to the stacking axis.

In such a known electro-distortion device, however, unsatisfactory operation may occur in damp or humid environments.

According to the present invention there is provided an electro-distortion device comprising a stack of laminations made of an electro-distortion material with respective electrodes included at different positions in the stack, each of which electrodes is sandwiched between two successive laminations of the electro-distortion material, and externally accessible connection means operable to apply on electrical potential between successive electrodes in the stock, thereby to bring about a change in the extent of the stack along its stacking axis, characterised in that the stack is surrounded with insulating material.

Reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows a longitudinal sectional view of an electro-distortion device embodying the present invention;

Figure 2 shows a partial perspective view of a printing head, in which the device of Figure 1 may be employed; and

Figures 3A and 3B show plan and side views respectively of a printing device used in the printing head of Figure 2.

Figure 1 illustrates an electro-distortion device, embodying the present invention, which is suitable for use in an actuator for driving a dot-impact printing wire or rod in a printing head. This electro-distortion device comprises a plurality of sheets 21 which are made of an electro-distortion material such as a piezo-electric ceramic, stacked together with laminar electrodes 22 therebetween. A first group of alternately arranged electrodes 22 are connected to a lead 24a and insulated from the other electrodes 22 by beads 25 which are made of an electrically insulating material, such as glass. The other group of alternate electrodes 22 are connected to a second lead 24b and insulated from the first group of electrodes 22 in the same manner as above. The laminations comprising the sheets of electro-distortion material 21 and the electrodes 22 are enclosed within an insulating resin material 23, such as an epoxy resin.

In use, an operating voltage is applied between the leads 24a and 24b, causing longitudinal electrostrictive expansion or contraction of the stock of laminations.

In the device of Figure 1, the insulating resin material 23 is itself also enveloped in a metal cover 31. This metal cover 31 can be formed by vaporizing an appropriate metal, such as aluminium, onto

09/25/2002, EAST Version: 1.03.0002

the insulating resin material 23, thus inhibiting the ingress of moisture into the electro-distortion device by virtue of the high moisture-proof characteristics of such a metal cover. The insulating resin material 23 prevents short-circuits between adjacent electrodes 22 that would otherwise be caused by the metal cover 31. As a result, the groups of electrodes 22 are not prone to becoming electrically connected to each other due to migration effects, for example, even if the device is used in a moist environment, ensuring that the device has a desirably high inherent reliability.

Figure 2 shows a printing head 10 of a dot-impact printer suitable for employing an electro-distortion device embodying the invention as an actuator 3. The printing head 10 comprises a cylindrical housing 20 and a plurality of printing devices 30 arrayed around and extending radially within the cylindrical housing 20.

AS shown in more detail in Figures 3A and 3B, each of the devices 30 comprises a base member 1, a movable member 11, and an actuator (electro-distortion device) 3. The movable member 11 comprises a flat leaf spring made of an appropriate resilient material having one end rigidly secured to the base member 1 at a fixing position B and a free remote end on which a dot-printing member (dot-printing pin or wire) 4 is mounted. A predetermined number of such dot-printing members 4 cooperate to constitute a dot matrix. As may be seen in the plan view of Figure 3A, the movable member 11 is gradually tapered, along substantially its entire length, from the fixing portion B to the free end thereof.

The actuator 3 has one end (the bottom of the stack of laminations) rigidly secured to the base member 1 and the other end (the top of the stack of laminations) connected via a connecting member 5 to the movable member 11 at an actuating position A thereof. The actuating position A is relatively near to the position B at which the movable member 11 is fixed to the base member 1.

As seen in the plan view of Figure 3A, the region of the laminar movable member 11 that extends from the actuating position A to the fixing position B comprises two substantially triangular portions arranged laterally adjacent to one another, each of the portions having a base at the fixing position B and a truncated apex at the actuating position A. These two lateral portions are separated, as seen in the plan view, by a triangular-form aperture 12, having a base at the actuating position A and an apex at the fixing position B or in the vicinity thereof. In general, at least one such triangular-form aperture is desirable. As shown in the plan view of Figure 3A, the remaining part of the movable member 11 is gradually tapered from the actuating position A to the free end thereof.

When printing, electric power is supplied via a drive circuit (not shown) to the actuator 3 for a predetermined time. This causes the actuator 3 to be distorted in the upward direction (i.e. perpendicular to the flat movable member 11), thereby upwardly displacing the movable member 11 at the actuating position A. The movable member 11 is thus resiliently deformed between the actuating position A and the fixing position B, so that the movable member 11 is bent in a clockwise direction, as shown in Figure 3B, about a centre of rotation (0_2) near to the fixing position B. Owing to this movement of the movable member 11, the dot-printing member 4 is moved upward as shown by on arrow P in Figure 3B to perform a printing operation. The electric power supply to the actuator 3 is stopped just before the completion of the printing operation, and thus, after completion of printing, the movable member 11 is returned to its original position by the actuator 3.

Further details of the printing head described above will be found in European potent application no. 89306778.5, out of which the present application has been divided.

Claims

1. An electro-distortion device comprising a stack of laminations (21) made of on electro-distortion material with respective electrodes (22) included at different positions in the stack, each of which electrodes is sandwiched between two successive laminations of the electro-distortion material, and externally accessible connection means (24a, 24b) operable to apply an electrical potential between successive electrodes in the stack, thereby to bring about a change in the extent of the stack along its stacking axis, characterised in that the stack is surrounded with insulating material (23).

2. A device as claimed in claim 1, wherein the said insulating material (23) is enveloped by a metal cover (31).

3. A device as claimed in claim 2, wherein the said metal cover (31) has been formed by vaporising the metal onto the said insulating material (23).

4. A device as claimed in claim 2 or 3, wherein the said metal cover (31) is made of aluminium.

5. A device as claimed in any one of claims 1 to 4, wherein the said electro-distortion material is a piezo-electric ceramic.

09/25/2002, EAST Version: 1.03.0002

6. A device as claimed in any one of claims 1 to 5, wherein the said insulating material (23) comprises an epoxy resin.

09/25/2002, EAST Version: 1.03.0002

Fig. 1

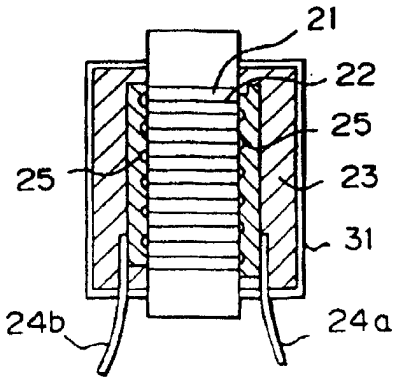
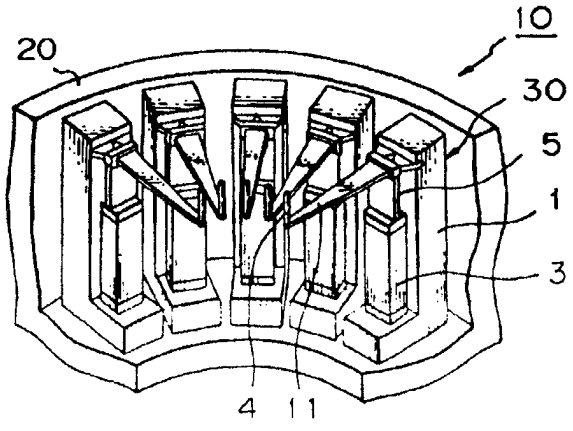


Fig. 2



09/25/2002, EAST Version: 1.03.0002

Fig. 3A

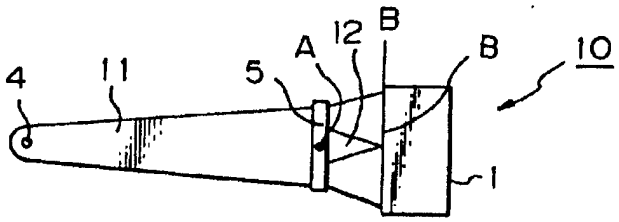
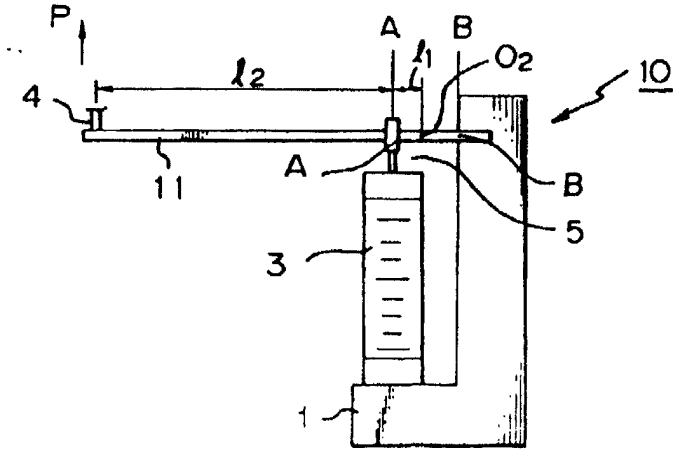


Fig. 3B



09/25/2002, EAST Version: 1.03.0002

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 11 5068

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 277 (E-640) 30 July 1988 & JP-A-63 056 971 (NIPPON SOKEN INC) 11 March 1988 * abstract *	1	B41J2/295
A	---	5,6	
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 357 (M-540) 2 December 1986 & JP-A-61 153 025 (NIPPON DENSO CO LTD) 11 July 1986 * abstract *	1,2,5	
A	---	1,2,5	
	PATENT ABSTRACTS OF JAPAN vol. 011, no. 110 (E-496) 7 April 1987 & JP-A-61 258 485 (AISAN IND CO LTD) 15 November 1986 * abstract *		
A	---	1,5	
	PATENT ABSTRACTS OF JAPAN vol. 011, no. 288 (E-542) 17 September 1987 & JP-A-62 088 382 (NEC CORP) 22 April 1987 * abstract *		TECHNICAL FIELDS SEARCHED (Int.Cl.5) B41J
A	---		
	PATENT ABSTRACTS OF JAPAN vol. 005, no. 023 (E-045) 12 February 1981 & JP-A-55 150 284 (NGK SPARK PLUG CO LTD) 22 November 1980 * abstract *		
A	---		
	PATENT ABSTRACTS OF JAPAN vol. 12, no. 218 (M-711) (3065) 22 June 1988 & JP-A-63 017 060 (NEC) 25 January 1988 * abstract *		

	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 January 1994	Adam, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 11 5068

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 95 (E-310) 24 April 1985 & JP-A-59 222 977 (NIPPON JIDOSHA BUHIN SOGO KENKYUSHO) 14 December 1984 * abstract * -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 January 1994	Adam, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)